

STEPPING MOTOR

The present invention relates to an electric stepping motor and, more particularly, to a stepping motor with an improved stator assembly.

Small electric stepping motors are known which
5 may be driven by periodic pulses produced by a transistorized driving circuit or other well known equivalent circuits. Regardless of the method by which it is driven, the stepping motor generally includes a main magnetic circuit formed of a
10 permanently magnetized rotor disposed in the air gap between spaced apart first and second stator members magnetically coupled to a coil. The excitation coil is magnetically coupled to the stator members usually by one or more magnetizable core members in the form
15 of simple rectilinear or U-shaped steel or iron plates extending through the coil and contacting the stator members.

One particular known stepping motor construction is shown in Figures 1 and 2 of the
20 accompanying drawings. The motor comprises a magnetically permeable (iron-nickel alloy) upper stator member 2 and lower stator member 4 with overlapping spoke-like pole pieces 2a and 4a and a rotor 6 in the form of a disc of hard magnetic material having a
25 high coercive field, e.g., a rare earth alloy. The rotor is supported by a central axle 8 for rotation in the air gap between the upper and lower stator members. The central axle in turn is supported by plastics bushing 11 moulded into a hole in the upper

stator member and a lower bushing 12 in a frame 14. A wound coil 16 having leads 16a receives energizing current, for instance pulses of constant sign, and is coupled to the upper and lower stator members via
5 L-shaped core members 18 having long portions 18a extending through the coil and short portions 18b extending transversely to contact the stator members. The aforementioned components of the stepping motor are stacked on support posts 14a of the frame and
10 held in position by screws 21, e.g., as shown in Figure 2. The motor is of the type described in US-PS 4,079,279 to which reference may be made for further details of its operation.

It is an object of the present invention to
15 increase the efficiency of a stepping motor of the type described above.

This and other objects and advantages are achieved in the present invention by providing a stable stator bridge for pivoting of the rotor
20 therebetween with minimal magnetic losses.

Briefly, the stepping motor of the invention includes a magnetically permeable first stator member mounted on a frame member, the first stator member having a central hub, multiple spoke-like pole pieces
25 radiating from the hub and central aperture in the hub through which one end of the rotor axle extends for rotation, preferably in a bushing located in the frame member. A stator bridge assembly is also mounted on the frame member and includes a plastics
30 holder member united to a magnetically permeable second stator member having a central hub and multiple

spoke-like pole pieces radiating from the hub in spaced, overlying relation to the hub and pole pieces of the first stator member to define a gap in which a rotor disc mounted on the central axle is disposed. The second stator member includes a central aperture in the hub axially aligned with the central aperture of the first stator member and portions of the plastics holder member are preferably thermoplastically worked to form a bushing in the aperture of the second stator member to rotatably receive the other end of the rotor axle. Other portions of the plastics holder member form a support bridge between the first and second stator members. The first and second stator members preferably each have an arm extending from at least one of the pole pieces for magnetic coupling to the excitation coil. The arms are arranged in non-overlapping relation so that they do not give rise to unwanted magnetic losses. Overlapping of other extraneous areas of the stator members (i.e., areas not associated with the hub or pole pieces) is eliminated to further reduce magnetic losses. A stable bridge for rotor pivoting with minimized magnetic losses is provided and results in significantly increased motor efficiency.

The invention will now be further described with reference to the accompanying drawings, in which:-

Figure 1 is an exploded view of a known stepping motor construction;

Figure 2 is a perspective view of the assembled stepping motor of Figure 1;

Figure 3 is an exploded view of an embodiment

of a stepping motor of the invention;

Figure 4 is a perspective view of the second stator member of the stator bridge assembly of Figure 3; and

5 Figure 5 is a perspective view of the stator bridge assembly of Figure 3 showing the inner sides of the second stator member and plastics holder member.

Referring to the drawings, Figure 3 shows an embodiment of a stepping motor of the invention having
10 an improved stator assembly. It is apparent from the figure that many of the other motor components are similar to those of the stepping motor shown in Figures 1 and 2 and like components are designated by like numerals primed. Both stepping motors are preferably
15 of the type illustrated in US-PS 4,079,279 which is incorporated herein by reference.

The stator assembly includes a magnetically permeable first stator member 20' having a central hub 20a', multiple, spoke-like pole pieces 20b'
20 radiating from the hub and a central aperture 20c' in the hub. As shown, one end of the rotor shaft 8' passes through the central aperture 20c' and is received in axially aligned bushing 12' in the frame member 14'. It is apparent that two of the pole pieces on the
25 left-hand side of the first stator member are extended to provide a ring motor arm 20d' projecting toward the coil 16' for contacting the short arm 18b' of the first core member 18'. The ring motor arm includes a hole 20e' through which support post 14a' passes. It is
30 apparent that the other pole pieces of the first stator

member 20' have not been extended to provide another ring motor arm on the right-hand side. This contrasts with the lower stator member 4 of Figure 1, and is an important feature of the stator assembly as explained
5 below.

Another important feature of the stator assembly is the provision of stator bridge 22' which comprises a magnetically permeable second stator member 23' similar in configuration to the first stator member;
10 i.e., having spoke-like pole pieces 23a' radiating from a central hub 23b' and having a central aperture 23c' in the hub, Figures 4 and 5. It is apparent that two of the pole pieces on the right-hand side (relative to Figure 3) of the second stator member have been
15 extended to provide a ring motor arm 23d' to contact the short arm 18b' of the adjacent core member. The assembly further comprises a non-magnetically permeable plastics holder member 24' united to the second stator member 23' by thermoplastic working techniques, for
20 example, warm forming, overmoulding or ultrasonic welding. As shown in Figures 3 and 5, a projecting portion 24a' of the plastics holder member overlaps one (outer) side 23e' of the second stator member and multiple tabs 24b' are thermoplastically formed to
25 engage the other (inner) side 23f' of the second stator member and thereby hold the components together. A bushing 24c' having a rim 24d' overlapping the inner side 23f' is also thermoplastically formed in the central aperture of the hub 23b' to rotatably receive
30 end 8a' of the rotor axle 8'. The lip of the bushing

also acts to hold the components together. The plastics holder member 24' is moulded or otherwise formed to provide a support bridge 24e' of sufficient thickness in the axial direction to contact the first stator member 20' when the motor is assembled. The plastics holder member is also moulded to provide a ring motor arm 24f' having a hole 24g' for receiving the fastening screw 21'.

It should be apparent that the stator bridge 22' in conjunction with the first stator member 20' eliminate magnetic losses experienced in the motor construction of Figures 1 and 2 because of extraneous magnetically permeable areas of the stator members; i.e., areas not associated with the hub and spoke-like pole pieces, overlapping one another. In the motor of the invention, the only overlapping areas of the stator members 20' and 23' are the central hubs and spoke-like pole pieces. The ring motor arms are not in overlapping relation and thus do not give rise to unwanted magnetic losses.

The stepping motor of the invention is mounted on a frame 14' by means of support posts 14a' and screws 21'. For example, the first stator member 20' is placed on the frame 14' with the support post extending through hole 20e' and with central aperture 20c' aligned with bushing 12'. Typically, the first stator member is glued to the frame 14'. The coil 16' with the core members 18' extending therethrough is stacked on the first stator member 20' with the slots 18c' receiving the posts 14a'. The stator bridge

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assembly 22' is placed over the arms of the core members with the hole 23g' in the second stator member receiving one support post 14a' and the hole 24g' in the plastics holder member receiving the other support
5 post. In this arrangement, the bushing 24c' of the stator bridge assembly is axially aligned with the central aperture 20c' of the first stator member and bushing 12' in the frame member 14', and the support
10 bridge 24e' contacts the inner side of the first stator member to provide a stable mechanical bridge between the first and second stator members. Of course, the rotor disc 6' mounted on central axle 8' is located in the air gap between the first and second stator
members, one end 8a' of the axle being received in the
15 bushing 24c' of the stator bridge assembly and the other end in the bushing 12' in the frame member 14'.

As a result of the stator assembly used, magnetic losses in the stepping motor are minimized. This results in a significant increase in stepping
20 motor efficiency, e.g., a stepping motor constructed in accordance with the invention will provide a 20% higher output torque at the same current level than a similar sized motor as shown in Figures 1 and 2.

CLAIMS:-

1. In a stepping motor of the type having first and second stator members in spaced apart, overlapping relation to define a gap therebetween in which a rotor disc is mounted on a central axle for rotation and having a coil magnetically coupled to the first and second stator members, the improvement comprising:

- (a) a magnetically permable first stator member having a central hub, multiple spoke-like pole pieces radiating from the hub and a central aperture in the hub through which one end of the rotor axle extends for rotation;
- (b) a stator bridge assembly comprising a magnetically permeable second stator member having a central hub and multiple spoke-like pole pieces radiating from the hub in spaced, overlapping relation to the hub and pole pieces of the first stator member and further comprising a non-magnetically permable plastics holder member united to the second stator member, said second stator member having a central aperture in the hub axially aligned with the central aperture of the first stator member and said plastics holder member having portions forming a bushing in the central aperture of second stator member for receiving the other end of the rotor axle with remaining portions of the plastics holder member forming a support bridge between the first and second



stator members;

and

- (c) means for holding the stator bridge assembly and first stator member together.

2. A stepping motor according to Claim 1 wherein the plastics holder member includes thermoplastically worked portions forming said bushing in the central aperture of the second stator member and also forming connecting tabs to engage the second stator member and unite it to the holder member.

3. A stepping motor according to Claim 1 wherein the means for holding the stator bridge assembly and first stator member together comprises a frame member supporting the first stator member and having a bushing axially aligned with the central aperture of said first stator member to receive said one end of the rotor axle, and means for clamping the stator bridge assembly and first stator member against the frame member in stacked relation.

4. In a stepping motor of the type having first and second stator members in spaced apart, overlapping relation to define a gap therebetween in which a rotor disc is mounted on a central axle for rotation and having a coil magnetically coupled to the first and second stator members, the improvement comprising:

- (a) a frame member carrying a bushing;
- (b) a magnetically permeable first stator member disposed on the frame member and having a central hub, multiple spoke-like pole pieces radiating from the hub and a central aperture





in the hub aligned with the bushing and through which one end of the rotor axle extends for rotation in said bushing, and further having an arm extending from at least one of said pole pieces for magnetic coupling to the coil;

- (c) a stator bridge assembly comprising a magnetically permeable second stator member having a central hub and multiple spoke-like pole pieces radiating from the hub in spaced, overlapping relation to the hub and pole pieces of the first stator member and having an arm extending from at least one of said pole pieces in spaced, non-overlapping relation to the arm of said first stator member, and further comprising a non-magnetically permeable plastics holder member united to the second stator member, said second stator member having a central aperture in the hub axially aligned with the central aperture of the first stator member and said plastics holder member having thermoplastically worked portions forming a bushing in the central aperture of second stator member for receiving the other end of the rotor axle with remaining portions of the plastics holder member forming a support bridge between the first and second stator members; and

- (d) means for holding the stator bridge assembly and first stator member together on the frame member.

5. A stepping motor substantially as hereinbefore described with reference to Figures 3 to 5 of the accompanying drawings.